



# **Can GM crops contribute to food security and sustainable agricultural development?**

***Evidence from 20 years of impact research***

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# Why more agricultural technology?

1. Environmental problems of agricultural production
2. Existing food insecurity
3. Growing global demand and resource scarcity
4. Many of the poor in Africa and Asia depend on small-scale farming as the key source of income



# Common approaches in plant breeding

§ Mass selection

§ Backcrossing

§ Wide crosses

§ Hybridization

§ Mutagenesis

§ Marker-assisted selection

§ Protoplast fusion

“Conventional breeding”

(“natural” and “safe”)

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§ Agrobacterium-mediated gene transfer

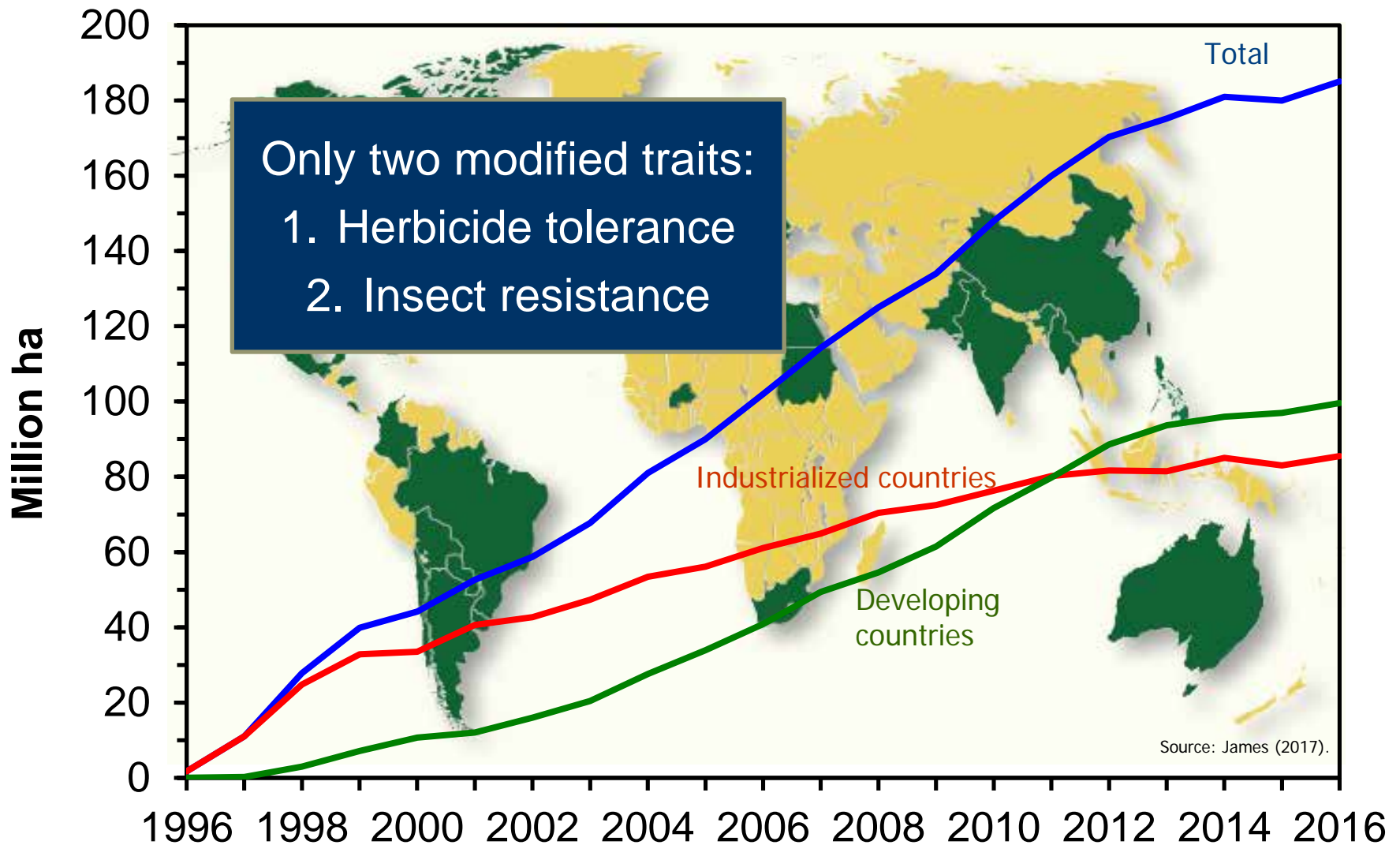
§ Biolistics

§ Genome editing (CRISPR/Cas etc.)

“Genetic engineering  
(GMOs)”

(“unnatural” and “risky”)

# Global area cultivated with GMOs

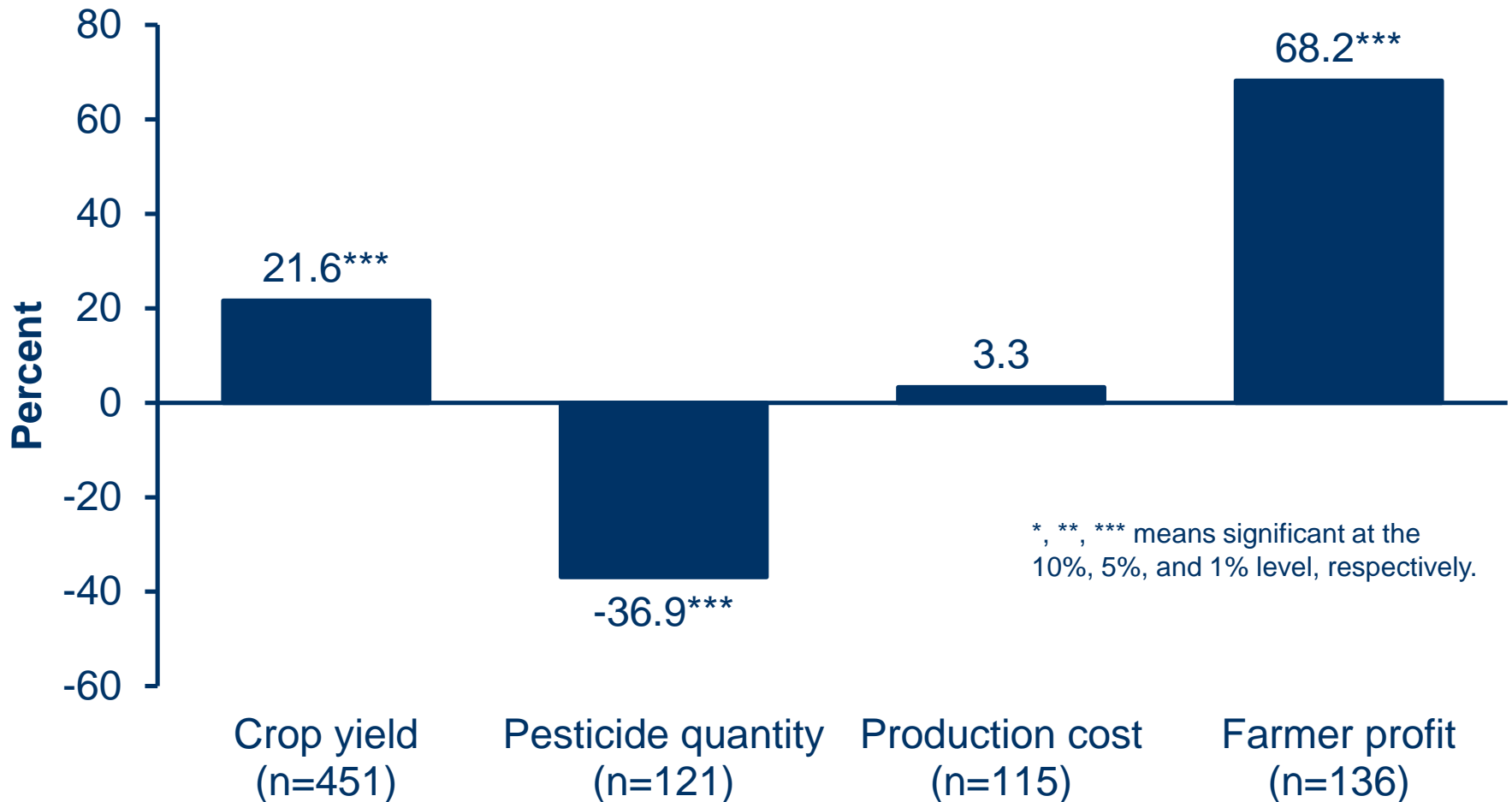


# Impact studies

- § Many impact studies carried out over the last 20 years:
  - ü Focusing on different countries
  - ü With different types of data
  - ü With different methodologies
  - ü With different results
  
- § GMO supporters and opponents refer to their “preferred studies” in the debate, leading to further polarization
  
- § Meta-analysis can be useful to:
  - ü Draw broader lessons from the cumulated evidence
  - ü Explain reasons for heterogeneity in impacts

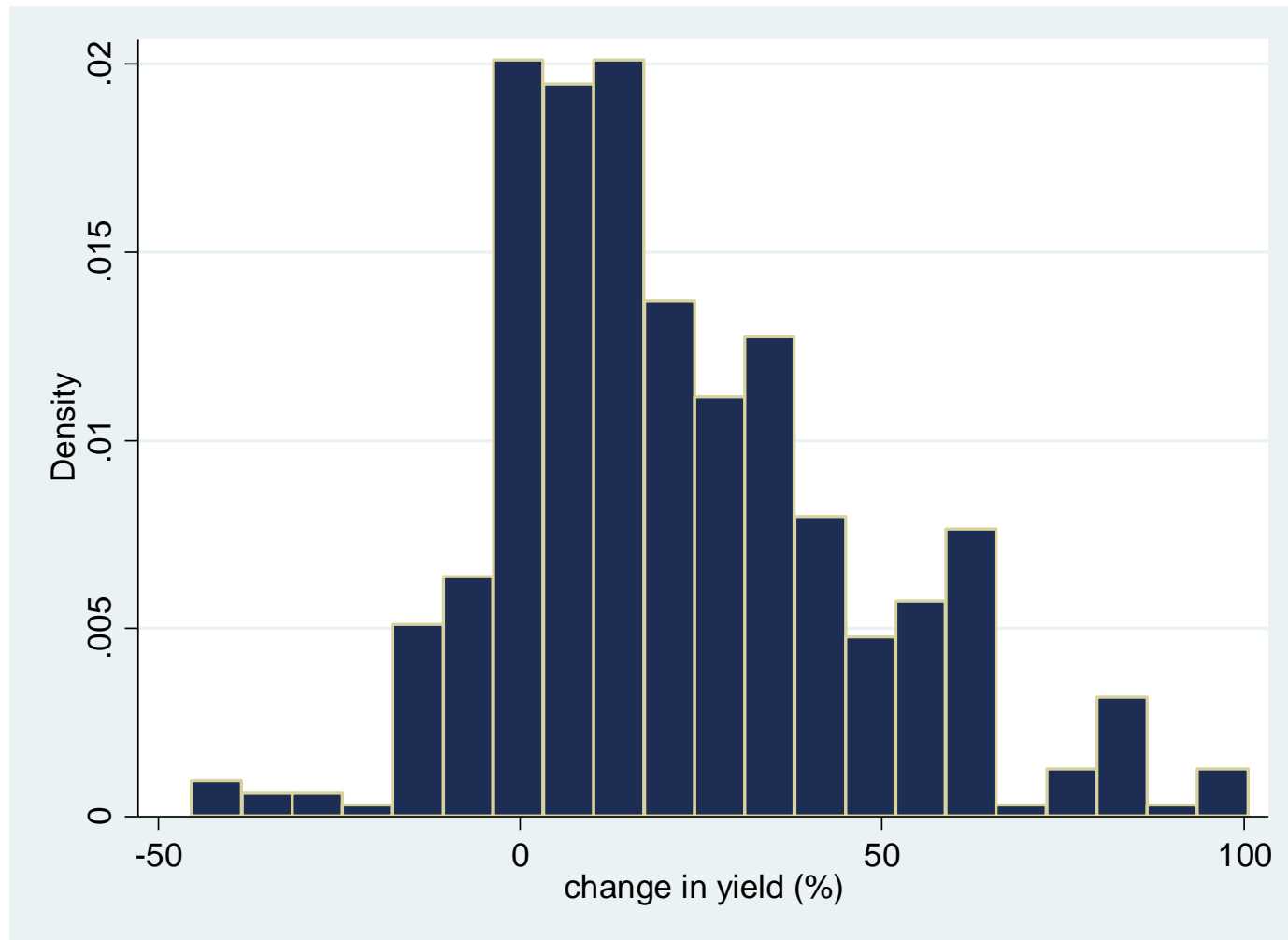
# Global meta-analysis of GM crop impacts

Klümper and Qaim (2014, *PLoS ONE*)



\*, \*\*, \*\*\* means significant at the 10%, 5%, and 1% level, respectively.

# Distribution of GM yield effects



Source: Klümper and Qaim (2014, PloS ONE).

# Meta-analysis

## Breakdown by type of technology

	(1) All GM crops	(2) Insect resistance	(3) Herbicide tolerance (HT)
Yield	21.6***	24.9***	9.3**
Pesticide quantity	-36.9***	-41.7***	2.4

Source: Klümper and Qaim (2014, PLoS ONE).

- HT has helped to reduce soil tillage and GHG emissions
- In some regions, weed resistance to glyphosate has reduced the benefits of HT crops over time



# Breakdown by geographical regions

## Meta-regression results (percentage point effects)

	Yield	Pesticide	Farmer profit
Developing country (dummy)	14.17***	-19.16***	59.52***
N	451	193	136

Source: Klümper and Qaim (2014, PLoS ONE).

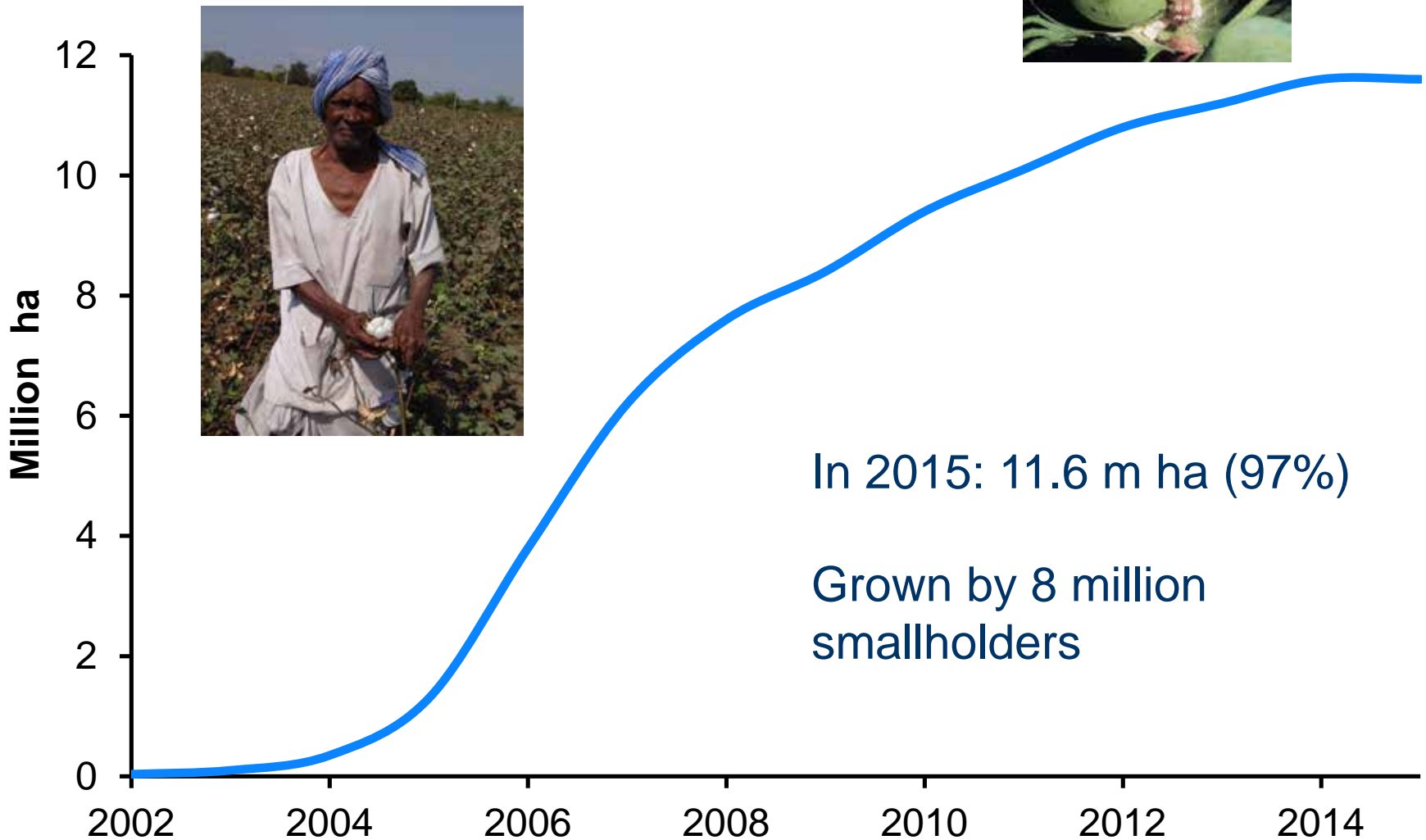
Developing-country farmers benefit more because:

1. They suffer more from pest and disease problems
2. Most GM technologies are not patented there, so that seed prices are cheaper than in developed countries

# What do we know about GM crop impacts in a small farm context?



# Bt cotton adoption in India



# Impact analysis with panel data

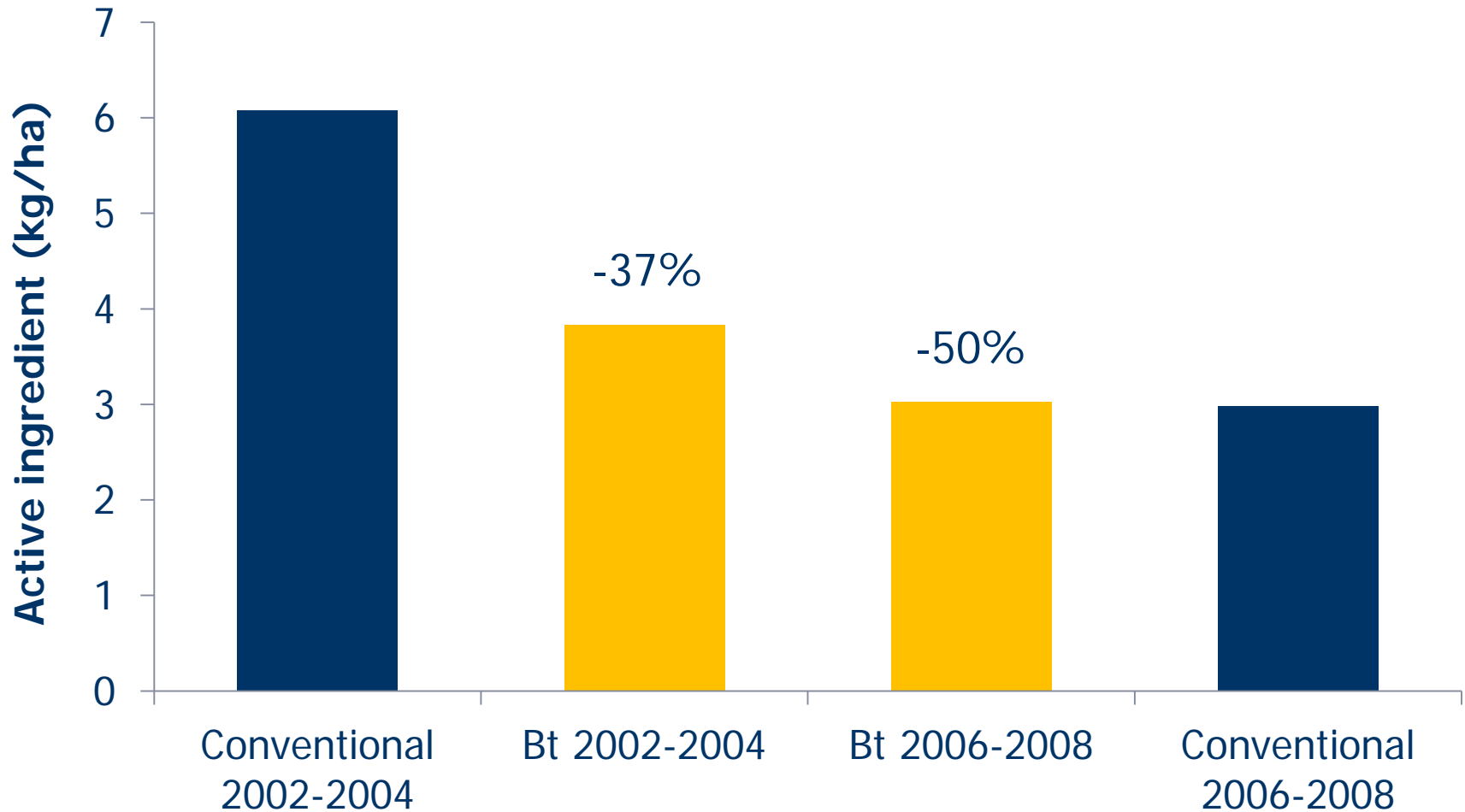
Survey of 530 farm households in four major cotton-producing states

Panel survey in four rounds between 2002 and 2009

Statistical differencing techniques to control for biases



# Bt impact on insecticide use



Source: Krishna and Qaim (2012, *Agric. Systems*).

# Bt impact on yield and farmer profit in India

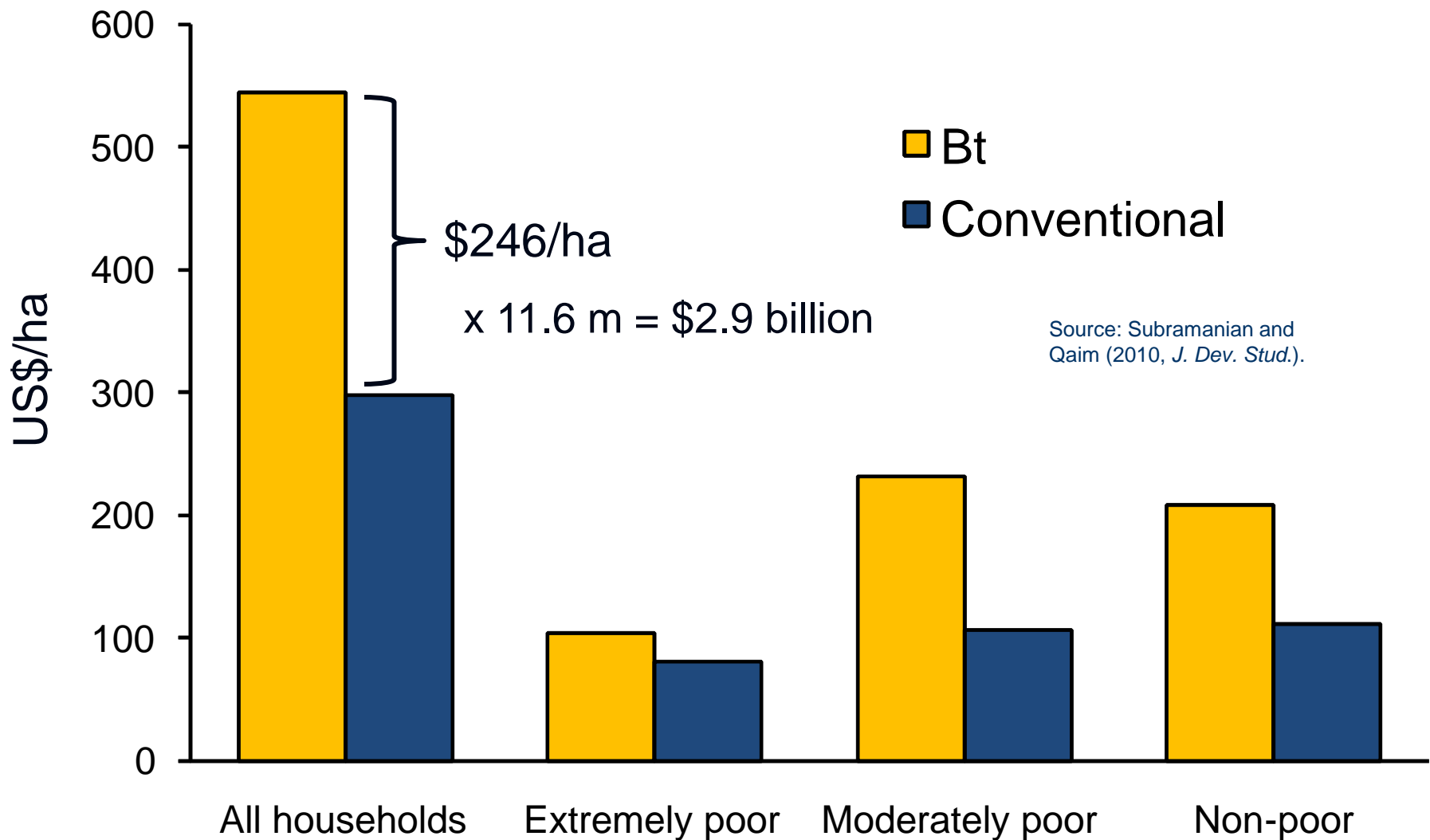
	Yield (kg/ha)	Profit (\$/ha)
Bt effect	311*** (+24%)	94*** (+50%)
Change over time	0 / +	0 / +

# Bt impact on household living standard

	Household consumption value (US\$)	Calorie consumption (kcal/person)	Calories from high-value food (kcal/person)
Bt effect	321** (+18%)	145*** (+5%)	47*** (+7%)

Sources: Kathage and Qaim (2012, *PNAS*), Qaim and Kouser (2013, *PLoS ONE*).

# Household income effects per ha of cotton



# Environmental and health effects of Bt

## Effects on pesticide use by toxicity class (per ha)

	Total	Tox I	Tox II	Tox III & IV
Bt effect (2002-2004)	-2.74***	-1.38*	-1.21*	-0.15
Bt effect (2006-2008)	-4.42***	-2.67***	-1.63***	-0.15*

## Effects on cases of acute pesticide poisoning

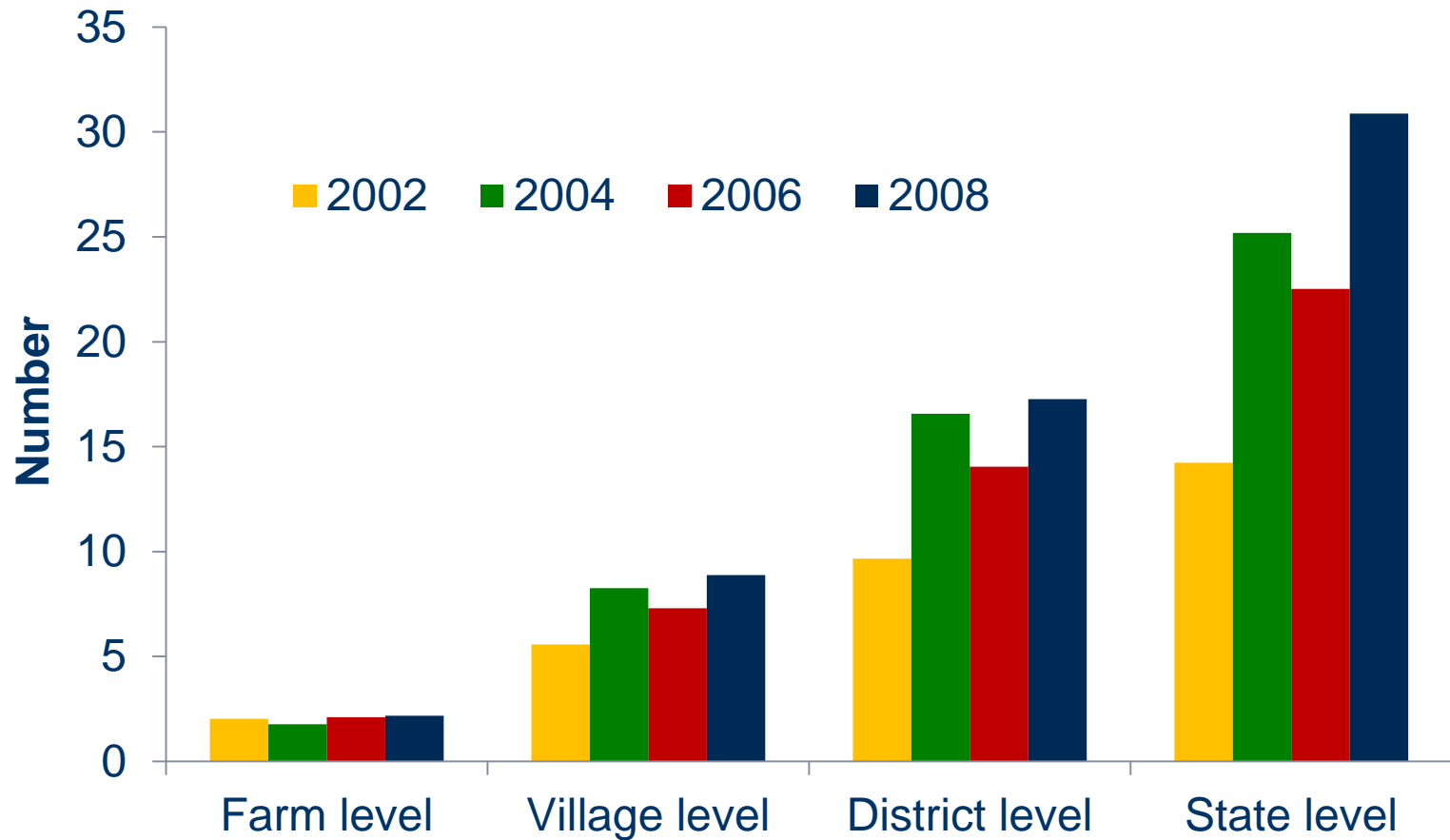
	Cases per ha	Cases in total India (million)
Bt effect	-0.26***	-2.98***

Source: Kouser and Qaim (2011, *Ecol. Econ.*),



# Effects on varietal diversity

## Mean number of cotton varieties grown by sample farms



Source: Krishna, Qaim, Zilberman (2016, *Eur. Rev. Agr. Econ.*).

# Future prospects

- § Evidence suggests that GM crops can be beneficial for farmers, consumers, and the environment.
- § So far, very limited range of GM technologies. Future technologies could be much more beneficial.
- § Many more interesting GM technologies tested in the field:
  - § Drought-tolerant and salt-tolerant maize, rice, and wheat
  - § Maize and rice with higher nitrogen use efficiency
  - § Micronutrient-rich rice, sorghum, cassava, and banana
  - § Pest- and disease-resistant rice, cassava, pulses, vegetables
  - § Etc.
- § Will these technologies ever be commercialized?

# Threat of overregulation

Many countries in Africa and Asia have established EU-style regulatory systems (and attitudes) that are stricter and more complex than for any other agricultural technology.

## Effects of overregulation

- § Fuels public notion that GM crops are dangerous
- § Makes technology unnecessarily expensive
- § Contributes to industry concentration (multinationals)
- § Contributes to focus on large countries, large crops, and traits of large commercial interest
- § Poor countries and people suffer most from overregulation
- § EU anti-biotech attitudes have far-reaching global implications

# Conclusion

- § GMOs are not a panacea, but there is strong evidence that they can contribute to food security and pro-poor growth
- § Without modern plant science in all its forms, sustainable development will hardly be possible
- § Like for any technology, there are certain issues that need to be addressed, but the strong public and policy reservations have no scientific basis

Further reading:  
Palgrave Macmillan, 2016

